

Christine A. Orme

PRESENT POSITION

Staff Scientist
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EDUCATION

Ph.D., Physics, University of Michigan, Ann Arbor, 1995
Thesis entitled: *Instabilities during MBE growth*, advisor Brad Orr.
B.S., Physics, University of California, Berkeley, 1986

RESEARCH AREAS: Biominerization, biomimetic synthesis, physics of assembly, corrosion, *in situ* methods for investigating interfacial dynamics.

POSITIONS

2005-2006	Acting Director for Physical Biosciences Institute, Lawrence Livermore National Laboratory
2005-2006	Scientific Capability Leader for Physical Biosciences group, Lawrence Livermore National Laboratory
1999-present	Physicist, Lawrence Livermore National Laboratory
2001-2004	Group leader for Passive Film component of the Yucca Mountain Project at Lawrence Livermore National Laboratory
2002-2005	Scientific Capability Leader for Biophysical and Interfacial Sciences group, Lawrence Livermore National Laboratory
2001- 2002	Acting Scientific Capability Leader for Biophysical and Interfacial Sciences group, Lawrence Livermore National Laboratory
1996-1999	Postdoctoral Fellow, Lawrence Livermore National Laboratory
1988-1995	Graduate Research Assistant, University of Michigan, Physics

HONORS

- 2002 Presidential Early Career Award for Science and Engineering (PECASE).
Citation: For her work on understanding the physical mechanisms of biominerization and the development of force microscopy-based methods of investigating mineralization at the nanoscale, (awarded in 2004)
- 2002 Office of Science Early Career Scientist and Engineer Award
- 2001 Science and Technology Award from Lawrence Livermore National Laboratory for work in biominerization (two awarded lab-wide per year)
- Lawrence Livermore National Laboratory achievement awards:
 - Excellence in publication award 2006
 - Special congratulatory award (for PECASE) 2004

- Energy & Environment certificate of accomplishment (for Yucca Mountain Project) 2004
- Excellence in publication award 2004
- Leadership achievement award 2003
- Scientific achievement award 2002

PROFESSIONAL

- Materials Research Society Meeting Chair Spring 2008
- Conference Organizing Committee International Summer School for Crystal Growth and Epitaxy 2007
- Materials Research Society Bulletin Volume Organizer 2006
- LLNL Leadership Development program 2005
- Fellowship board member, Institute of Complex Adaptive Matter, Santa Fe, NM 2003-
- Organizer for symposium "Biological and Bio-Inspired Materials and Devices" Spring MRS meeting, San Francisco, CA (4/2002 & 4/2004), "Biocrystallization", American Association of Crystal Growers (2003), "Modeling of Morphological Evolution at Surfaces and Interfaces", Fall MRS meeting, Boston, MA (12/2004).
- Invited discussion leader for: Control of nucleation and morphology, Thin film and crystal growth mechanisms, Mount Holyoke College, MA (6/2003), Symposium on Stress Proteins: From Antifreeze to Heat Shock, Bodega Bay, CA (3/2003)
- Reviewer for: Physical Review B, J. Phys Chem, J. Crystal Growth, Basic Energy Sciences, National Science Foundation, Biophysical Journal, J. Biomedical Research, Marine Biology Progress Series, Crystal Growth and Design, Acta Biomaterialia
- Interviewed by LLNL Public Relations Office on Tri-Valley public TV regarding biomineralization and PECASE award (2001 and 2004).
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GRANTS AWARDED

Dates and Funding to Orme lab

1. 06-LW-090 (Orme, PI)	10/1/05-9/30/08
Agency: DOE/LLNL	\$220,000/year

Understanding shape control during nanoparticle synthesis

The major goal of this project is to develop a methodology to understanding shape control in nanoparticle synthesis using a combined experimental and theoretical. The overarching goal is to determine the mechanisms by which ligands direct crystal growth processes at the atomic scale. Primary collaborators: Professor David Srolovitz, Princeton University.

2. 2 R01 DE03233-31 (Nancollas, PI)	7/1/2002 – 6/30/07
Agency: NIH/NIDCR	\$200,000/year

The Kinetics of Mineralization of Teeth

The major goal of this project is to understand how organic modifiers affect the energetics and kinetics of calcium phosphate mineralization.

Primary collaborators: Professor George Nancollas (SUNY, Buffalo), Professor John Hoyer (University of Pennsylvania School of Medicine and The Children's Hospital of Philadelphia), Dr. James J. De Yoreo (LLNL)

3. 2 R01 DK61673-01 (De Yoreo, PI)	4/1/2002 – 3/31/06
NIH/NIDDK	N/A

Molecular modulation of Calcium Oxalate Crystallization

The major goal of this award is to understand the role of urinary macromolecules in modifying calcium oxalate crystallization.

Primary collaborators: Professor George Nancollas (SUNY, Buffalo), Professor John Hoyer (University of Pennsylvania School of Medicine and The Children's Hospital of Philadelphia), Dr. James J. De Yoreo (LLNL)

4. 00-ERI-006 (Orme, PI) 10/1/99-10/30/02
Agency: DOE/LLNL \$90,000/year
Engineering Titanium for Improved Biological Response

The major goal of this award was to understand the role of titanium dioxide in preventing corrosion and promoting biological adhesion in physiological settings.

Primary collaborators: Dr. Jane Bearinger (LLNL), Professor Jeremy Gilbert (Syracuse University)

TEACHING/MENTORING/MANAGEMENT EXPERIENCE

- 2005-2006 Physical Biosciences Institute acting director – responsibilities included: recruiting, supervising, and mentoring a group of six postdoctoral researchers; managing the research and G&A budgets, managing University outreach (UEPP) proposal selection process, holding weekly meetings, writing personnel evaluations and representing the PBI to internal and external officials.
- 2001-2005: Biophysical and Interfacial Sciences group leader- line management responsibilities for 6 career scientists, 9 postdoctoral research associates, and 15 students. Responsibilities include: annual written performance evaluation, development of hiring and promotion packages, and weekly meetings to discuss scientific and personnel issues.
- Co-advised graduate student research in my lab:
 - Current - Alan Szmodis (Prof. Atul Parikh, UCD), Julie Muyco (Prof. Joanna McKittrick, UCSD), Pascale Leroueil (U. Michigan, Profs. Orr and Banaszak-Holl), Edin Chen (UCSD, Prof. Sungho Jin)
 - Graduated - Jane Bearinger (Northwestern, Prof. Jeremy Gilbert), Salvador Zepeda (UCD, Prof. Yin Yeh)
- 1999: Volunteer tutor for high school physics student
- 1988-1992: Teaching assistant for: first year physics, physics lab, electronics, thermodynamics, atomic physics – including weekly recitation sections and office hours.

PUBLICATIONS (33 papers with over 700 citations)

Graduate Work – Experiment and Modeling of surface evolution

1. Saarloos, J., Olson, S., Carithers, W., Haber, C., **Orme, C.** & Siegrist, J. *High-Voltage Control and Monitoring-System for Proportional Chambers*. IEEE Transactions on Nuclear Science 35, 191-192 (1988).
2. Hunt, A. W., **Orme, C.**, Williams, D. R. M., Orr, B. G. & Sander, L. M. *Instabilities in Mbe Growth*. Europhysics Letters 27, 611-616 (1994).

3. Johnson, M. D., **Orme, C.**, Hunt, A. W., Graff, D., Sudijono, J., Sander, L. M. & Orr, B. G. *Stable and Unstable Growth in Molecular-Beam Epitaxy*. Physical Review Letters 72, 116-119 (1994).
4. **Orme, C.**, Johnson, M. D., Sudijono, J. L., Leung, K. T. & Orr, B. G. *Large-Scale Surface-Structure Formed during Gaas (001) Homoepitaxy*. Applied Physics Letters 64, 860-862 (1994).
5. Orr, B. G., Johnson, M. D., **Orme, C.**, Sudijono, J. & Hunt, A. W. *The Surface Evolution and Kinetic Roughening during Homoepitaxy of Gaas (001)*. Solid-State Electronics 37, 1057-1063 (1994).
6. Proksch, R., Foss, S., **Orme, C.**, Sahu, S. & Moskowitz, B. *Magnetic Force Microscopy of Single-Crystal Magnetite (Fe_3O_4)*. Journal of Applied Physics 75, 6892-6892 (1994).
7. **Orme, C.**, Johnson, M. D., Leung, K. T. & Orr, B. G. *Atomic-Force Microscopy and Scanning-Tunneling-Microscopy Studies of Large-Scale Unstable Growth Formed during Gaas(001) Homoepitaxy*. Materials Science and Engineering B-Solid State Materials for Advanced Technology 30, 143-148 (1995).
8. **Orme, C.**, Johnson, M. D., Leung, K. T., Orr, B. G., Smilauer, P. & Vvedensky, D. *Studies of Large-Scale Unstable Growth Formed during Gaas(001) Homoepitaxy*. Journal of Crystal Growth 150, 128-135 (1995).
9. **Orme, C.** & Orr, B. G. *Surface evolution during MBE growth*. Surface Review and Letters 4, 71-105 (1997).

Ice

10. Zepeda, S., Yeh, Y. & **Orme, C. A.** *Atomic force microscope chamber for in situ studies of ice*. Review of Scientific Instruments 72, 4159-4163 (2001).
11. Noy, A., Zepeda, S., **Orme, C. A.**, Yeh, Y. & De Yoreo, J. J. *Entropic barriers in nanoscale adhesion studied by variable temperature chemical force microscopy* (vol 125, pg 1356, 2003). Journal of the American Chemical Society 125, 3668-3668 (2003).

Biomineralization

12. Teng, H. H., Dove, P. M., **Orme, C. A.** & De Yoreo, J. J. *Thermodynamics of calcite growth: Baseline for understanding biomineral formation*. Science 282, 724-727 (1998).
13. **Orme, C. A.**, Noy, A., Wierzbicki, A., McBride, M. T., Grantham, M., Teng, H. H., Dove, P. M. & DeYoreo, J. J. *Formation of chiral morphologies through selective binding of amino acids to calcite surface steps*. Nature 411, 775-779 (2001).
14. Tang, R. K., Nancollas, G. H. & **Orme, C. A.** *Mechanism of dissolution of sparingly soluble electrolytes*. Journal of the American Chemical Society 123, 5437-5443 (2001).
15. Tang, R. K., **Orme, C. A.** & Nancollas, G. H. *A new understanding of demineralization: The dynamics of brushite dissolution*. Journal of Physical Chemistry B 107, 10653-10657 (2003).
16. Qiu, S. R., Wierzbicki, A., **Orme, C. A.**, Cody, A. M., Hoyer, J. R., Nancollas, G. H., Zepeda, S. & De Yoreo, J. J. *Molecular modulation of calcium oxalate crystallization by osteopontin and citrate*. Proceedings of the National Academy of Sciences of the United States of America 101, 1811-1815 (2004).
17. Tang, R. K., **Orme, C. A.** & Nancollas, G. H. *Dissolution of crystallites: Surface energetic control and size effects*. Chemphyschem 5, 688-696 (2004).
18. Tang, R. K., Wang, L. J., **Orme, C. A.**, Bonstein, T., Bush, P. J. & Nancollas, G. H. *Dissolution at the nanoscale: Self-preservation of biominerals*. Angewandte Chemie-International Edition 43, 2697-2701 (2004).
19. Fu, G., Qiu, S. R., **Orme, C. A.**, Morse, D. E. & De Yoreo, J. J. *Acceleration of calcite kinetics by abalone nacre proteins*. Advanced Materials 17, 2678-+ (2005).
20. Qiu, S. R., Wierzbicki, A., Salter, E. A., Zepeda, S., **Orme, C. A.**, Hoyer, J. R., Nancollas, G. H., Cody, A. M. & De Yoreo, J. J. *Modulation of calcium oxalate*

- monohydrate crystallization by citrate through selective binding to atomic steps.* Journal of the American Chemical Society 127, 9036-9044 (2005).
21. Tang, R. K., Darragh, M., **Orme, C. A.**, Guan, X. Y., Hoyer, J. R. & Nancollas, G. H. *Control of biominerization dynamics by interfacial energies.* Angewandte Chemie-International Edition 44, 3698-3702 (2005).
 22. Wang, L. J., Tang, R. K., Bonstein, T., **Orme, C. A.**, Bush, P. J. & Nancollas, G. H. *A new model for nanoscale enamel dissolution.* Journal of Physical Chemistry B 109, 999-1005 (2005).
 23. Kim, I. W., Darragh, M. R., **Orme, C. A.** & Evans, J. S. *Molecular “tuning” of crystal growth by nacre-associated polypeptides.* Cryst. Growth and Design 6, 5-10 (2006)
 24. Tang, R. K., Giocondi, J., Hoyer, J., Orme, C.A., Nancollas, G. H., *Dual roles of brushite crystals in calcium oxalate renal stone formation*, Kidney International (accepted).

Metal/Metal-oxide Interactions

25. Bearinger, J. P., **Orme, C. A.** & Gilbert, J. L. *Direct observation of hydration of TiO₂ on Ti using electrochemical AFM: freely corroding versus potentiostatically held conditions.* Surface Science 491, 370-387 (2001).
26. Bearinger, J. P., **Orme, C. A.** & Gilbert, J. L. *Effect of hydrogen peroxide on titanium surfaces: In situ imaging and step-polarization impedance spectroscopy of commercially pure titanium and titanium, 6-aluminum, 4-vanadium.* Journal of Biomedical Materials Research Part A 67A, 702-712 (2003).
27. Bearinger, J. P., **Orme, C. A.** & Gilbert, J. L. *In situ imaging and impedance measurements of titanium surfaces using AFM and SPIS.* Biomaterials 24, 1837-1852 (2003).
28. Schuh, C. A., Anderson, K. & **Orme, C.** *Rapid assessment of anisotropic surface processes: experiments on the corrosion of Inconel 600.* Surface Science 544, 183-192 (2003).
29. J. Gray, J. Hayes, G. Gdowski, B. Viani, & **C. A. Orme**, *Influence of solution pH, anion concentration and temperature on the corrosion properties of alloy 22*, J. Electrochemical Soc. 153, 3, B61-B67, (2006).
30. J.R. Hayes, J. J. Gray, A. Szmodis, and **C. A. Orme**, *Influence of Chromium and Molybdenum on the Corrosion of Nickel Based Alloy Systems*, Corrosion, (in press)
31. J.J. Gray, J. R. Hayes, G. E. Gdowski, and **C. A. Orme**, *Inhibiting effects of nitrates on the passive film breakdown of alloy 22 in chloride solutions*, J. Electrochemical Soc. 153, B156-B161, (2006).
32. Gray, J.J., El Dasher, B.S., **Orme, C.A.**, *Competitive effects of metal dissolution and passivation modulated by surface structure: An AFM and EBSD study of the corrosion of alloy 22*, Surface Science (in press).
33. Chen, I. C., Chen, L. H., Ye, X. R., Daraio, C., Jin, S., **Orme, C. A.**, Quist, A. & Lal, R. *Extremely sharp carbon nanocone probes for atomic force microscopy imaging.* Applied Physics Letters 88, - (2006).

Articles written about our work:

- *Small science gets to the heart of the matter*, LLNL Science and Technology Review (12/2001) <http://www.llnl.gov/str/December01/December01.html>.
- L. Addadi and S. Weiner, *Crystals, asymmetry and Life*, News and Views, Nature **411**, 753 (6/2001).
- *Scientists get a handle on crystal shape*, Science News **159**, 373 (6/2001)

- *Chiral Amino Acids Alter Mineral structure*, C&EN: News of the Week (6/2001)
- *Metal and metal-oxide interfaces in corrosive environments*, Chemistry and Material Science Directorate Annual Report 2003 (http://www-cms.llnl.gov/news/ann_rpt/cms_ann_rpt_03.pdf).

INVITED PRESENTATIONS

- C. Orme, S. Orme, H. H. Teng, P. M. Dove and J. J. De Yoreo, *In Situ Atomic Force Microscopy Studies of Surface Morphology and Kinetics During the Growth of CaCO₃*, Sixteenth Conference on Crystal Growth and Epitaxy, Fallen Leaf Lake, CA, June 7-10, 1998.
- C.A. Orme, *In situ studies of calcite and brushite*, Physics Department Colloquium, University of Wisconsin, August 1999
- C. Orme, H. Teng, P. Dove, J. J. DeYoreo, A. Hina, G. Nancollas, *In Situ Studies of Calcite and Brushite*, American Conference on Crystal Growth and Epitaxy -11, Tucson, AZ, August 1-6, 1999.
- C.A. Orme, *In situ atomic force microscopy investigation of biomineral surfaces*, Chemistry Department Seminar, SUNY Buffalo, December 7, 2000
- C.A. Orme, *In situ atomic force microscopy investigation of biomineral surfaces*, University of Michigan, Condensed Matter Physics Seminar, December 2000
- Christine Orme, *Experimental Methods for investigating crystal-fluid interfaces*, Material Research Society Tutorial, S.F., CA, April 23, 2000.
- C. A. Orme *Probing crystal growth using chiral molecule*, Gordon Research Conference, Thin films and crystal growth mechanisms, Williamstown, MA (2001).
- C. A. Orme *Chiral morphology of calcite through selective binding of amino acids*, American Physical Society, Indianapolis, IN (2002)
- C. A. Orme, A. Noy, A. Wierzbicki, M. McBride, J. J. De Yoreo, *Using Chiral Molecules to Probe Mineralization*, American Crystallographic Association, San Antonio, TX (2002)
- C. Orme, K. Anderson, S. Szmodis, T. Lian, J. Farmer, *Oxides Films formed on Alloy 22 in air and in aqueous electrolytes*, Nickel Developer's Institute, Las Vegas, NV (10/2002)
- C. Orme, K. Anderson, S. Szmodis, T. Lian, J. Farmer, *Passive Films*, BES Corrosion Contractors Meeting Upton, NY (9/2002)
- C. Orme, *Biomineralization*, Dept. of Physics, Brookhaven National Lab, Upton, NY (9/2002)
- C. A. Orme, A. Noy, A. Wierzbicki, M. McBride, J. J. De Yoreo, M. Grantham, P. Dove, and H. Teng, *Using Chiral Molecules to Probe Mineralization*, American Chemical Society, New Orleans, LA (4/2003)
- C. A. Orme, K. L. Anderson, J. R. Hayes, A. Szmodis, J. P. Bearinger, C. Schuh, and J. L. Gilbert, *Morphological transitions in metal/metal-oxide systems*, National Association of Corrosion Engineers, New Orleans, LA, March 28-April 1, 2004
- Christine Orme, Roger Qiu, Molly Darragh, Andre Wierzbicki, Aleksandr Noy, James De Yoreo *Stereochemical recognition during biomimetic mineralization: A paradigm revisited*, Institute of Complex Adaptive Matter, Santa Fe, NM (4/2004)
- Christine Orme, Roger Qiu, Molly Darragh, Andre Wierzbicki, Aleksandr Noy, James De Yoreo, *Atomic force microscope studies of crystal growth mechanisms during biomimetic mineralization*, Univ. Washington, Physics Dept. Colloquium, Pullman, WA 4/2004
- Christine Orme, Roger Qiu, Molly Darragh, Andre Wierzbicki, Aleksandr Noy, James De Yoreo, *Molecular Modulation of mineral steps by Organic molecules*, European Geochemical Union 2004, Nice, France, (4/2004)
- M. Darragh, J. Giocondi, I. Kim J. S. Evans, S. R. Qiu, J. J. De Yoreo and C. Orme, *Biomimetic mineralization – how bones and shells get their shape*, University of California, Chemical Engineering Seminar, Davis, CA (2/2005)

- Christine Orme, R Qiu, M. Darragh, J. Giocondi, R. Tang, J. De Yoreo, G. H. Nancollas, *Biomineralization – nature's way of crystallizing*, Univ. Michigan, Physics Dept. Colloquium, Ann Arbor, MI 2/2005
- Christine Orme, R Qiu, M. Darragh, J. Giocondi, R. Tang, J. De Yoreo, G. H. Nancollas, Biominerization Tutorial, Univ. of California San Francisco, Dental School, SF, CA 4/2005
- Christine Orme, J. Giocondi, S. R. Qiu, M. Darragh, R. Tang, J. De Yoreo, G. H. Nancollas, *Unexpected energetic controls*, American Association of Crystal Growers, Big sky, MO 7/11/2005
- Chris Orme, Jennifer Giocondi, Molly Darragh, Roger Qiu, Jim DeYoreo, "A Molecular View of Adsorbate Effects during Biominerization, 2006 TMS Annual Meeting, San Antonio, TX summer, 2006
- Chris Orme, A molecular view of adsorbate effects during crystallization, Electrodeposition Gordon Research Conference, Colby-Sawyer College, New London, New Hampshire from July 30 until August 4, 2006

As well as others presented by my collaborators Jim De Yoreo, Patricia Dove, John Evans, and George Nancollas.

REFERENCES (available upon request)

Thesis advisor:

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